Observations of Groundwater Depletion from Space: Challenges in California and the United States

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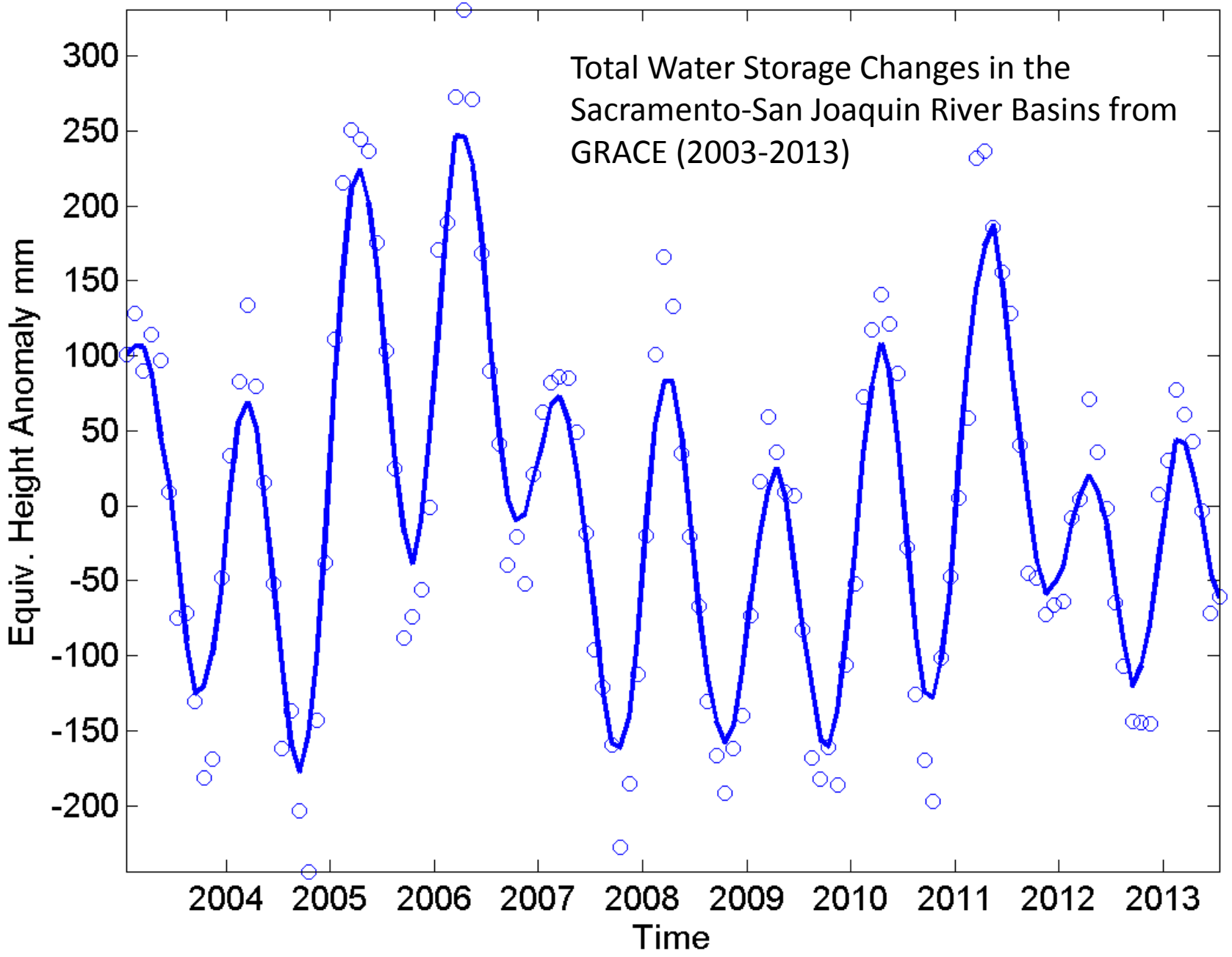
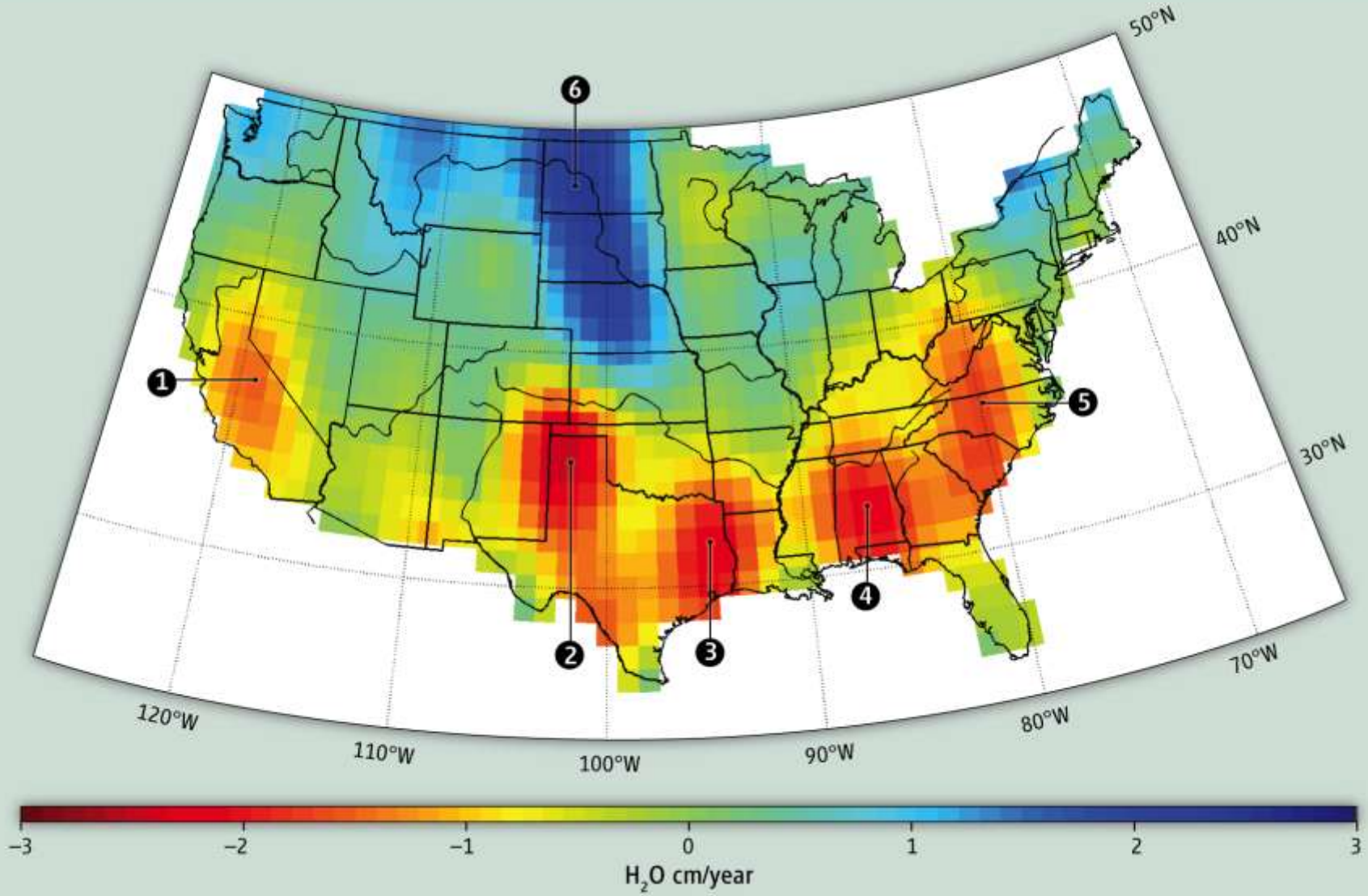
NASA Gravity Recovery and Climate Experiment (GRACE)

- Launched in 2002 with a nominal 5-year lifetime (still working)
- Follow-on (GRACE-FO) scheduled for 2017
- Measures changes in Earth's gravity field (really, in the distribution of mass)
- On land, these mass/gravity are dominated by changes in total water storage, from which groundwater can be isolated
- Functions like a 'scale in the sky' that can weigh the *monthly* increase or decrease in water storage in a *large (>200,000 km^2)* region with an accuracy of 1.5 cm

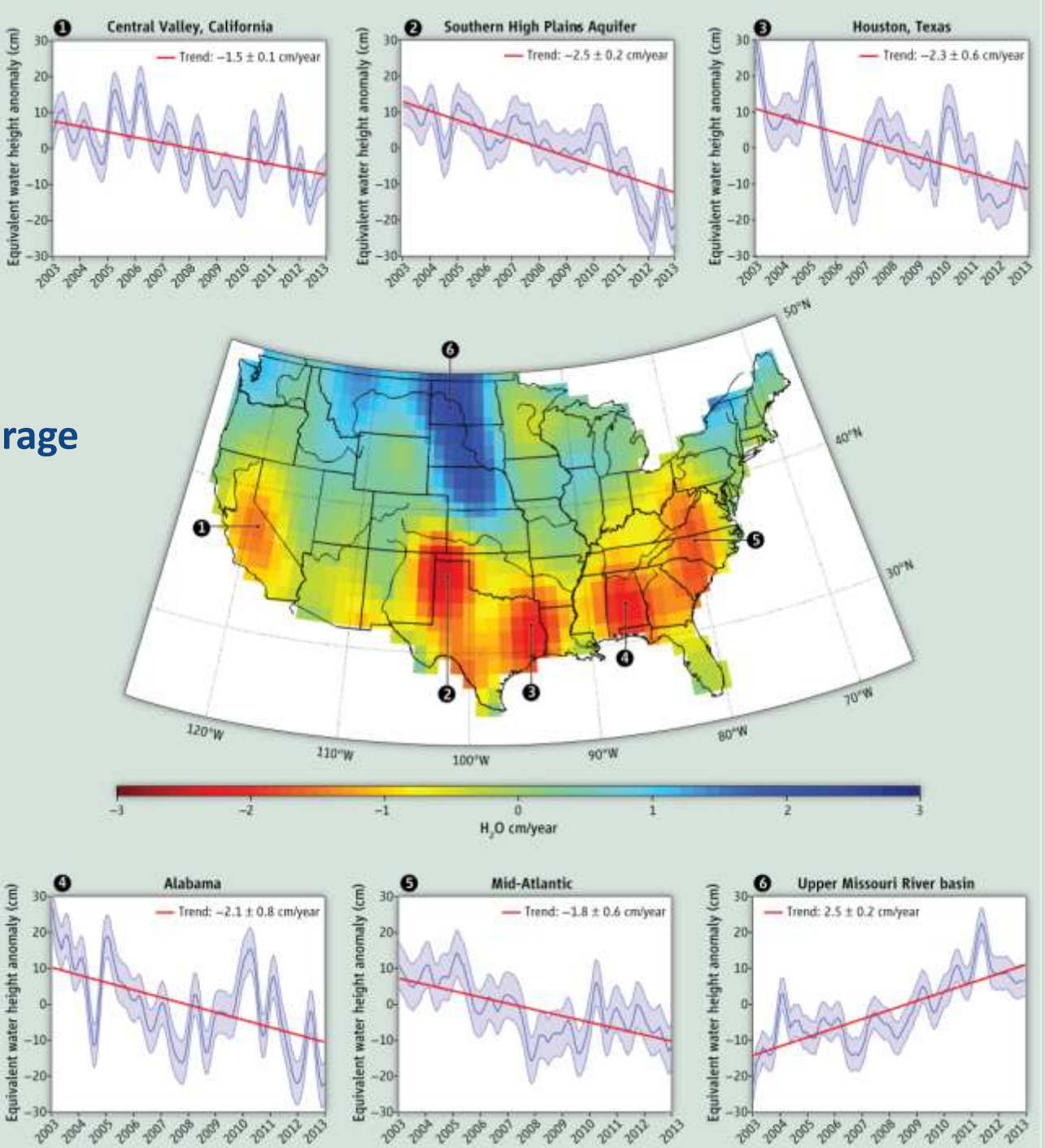

Total Water Storage Changes in the Sacramento-San Joaquin River Basins from GRACE (2003-2013)
Equiv. Height Anomaly mm
300
250
200
150
100
50
0
-50
-100
-150
-200
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Time

Trends in Freshwater Storage from GRACE, 2003-2012



From 'Water in the Balance,' Famiglietti and Rodell, 2013

Trends in Freshwater Storage from GRACE, 2003-2012



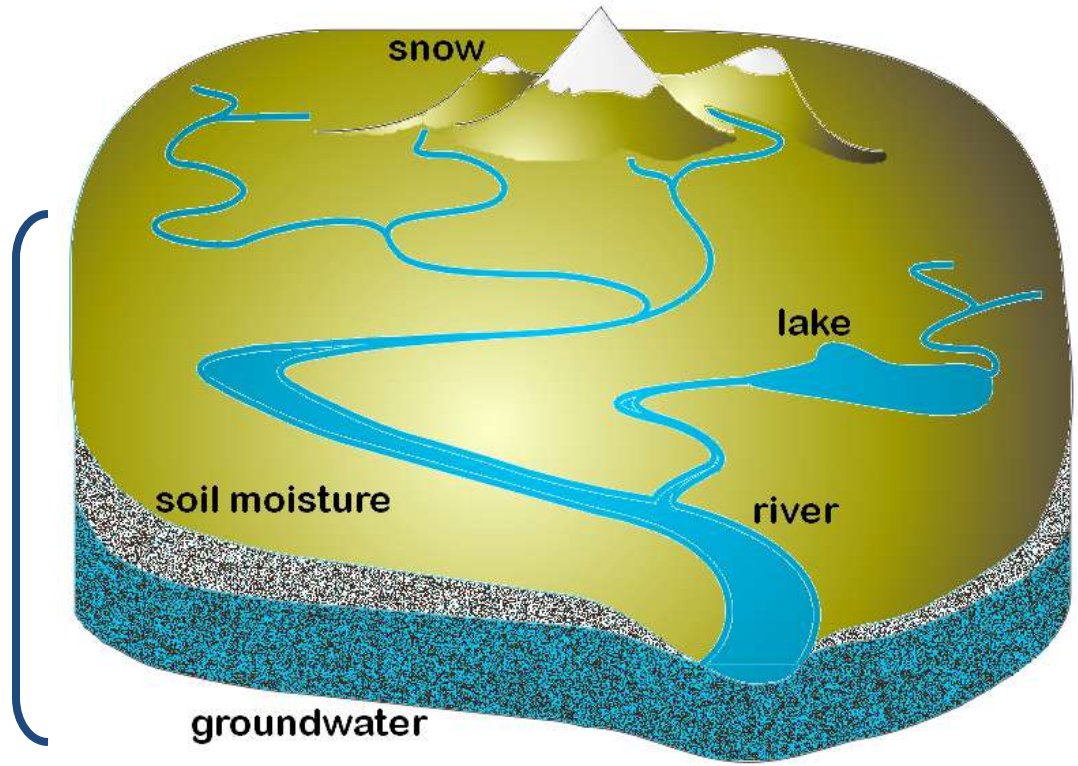
From 'Water in the Balance,' Famiglietti and Rodell, 2013

Estimating groundwater storage changes with GRACE

$$\Delta S_{Total} = \Delta S_{Snow} + \Delta S_{Surface\ Water} + \Delta S_{Soil\ Moisture} + \Delta S_{Groundwater}$$

$$\Delta S_{Groundwater} = \Delta S_{Total} - \Delta S_{Snow} - \Delta S_{Surface\ Water} - \Delta S_{Soil\ Moisture}$$

ΔS_{Total}

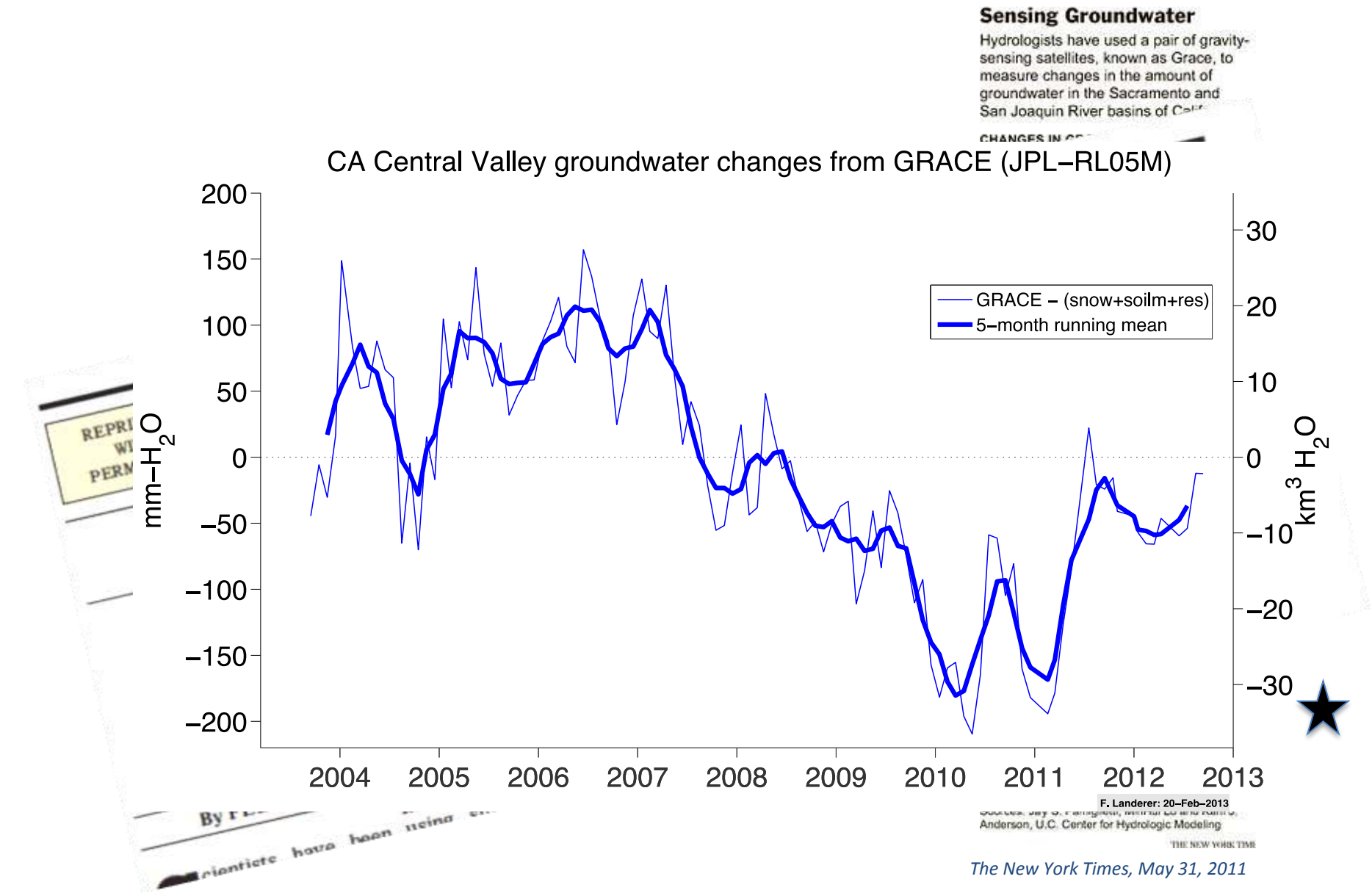


Remove this
($\Delta S_{Snow} + \Delta S_{Surface\ Water} + \Delta S_{Soil\ Moisture}$)

from
ΔS_{Total}…

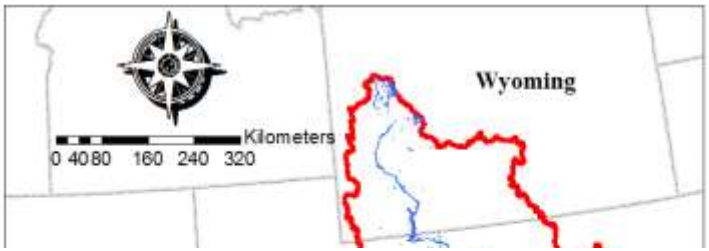
To isolate this
($\Delta S_{Groundwater}$)

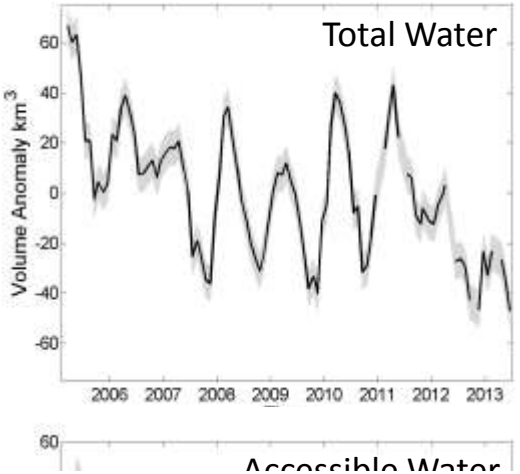
Groundwater depletion in California's Central Valley, October, 2003-March, 2009



The New York Times, May 31, 2011

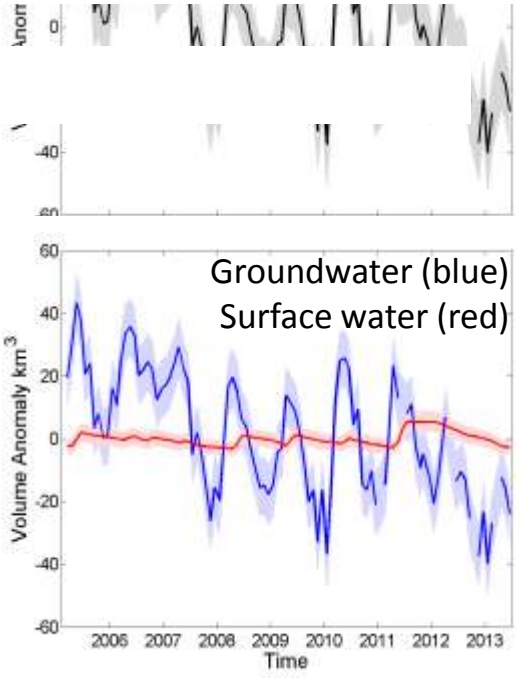
Groundwater use in the Colorado River Basin during drought (2005-2013)



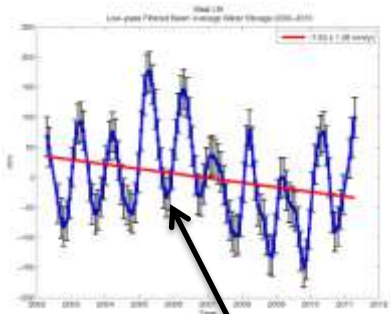


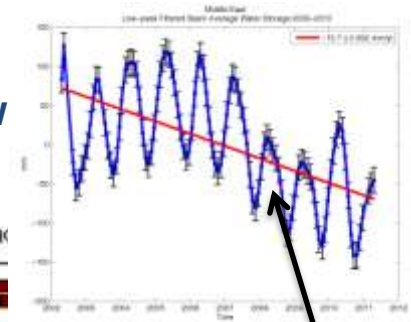
Q: Will declining groundwater reserves in the Colorado River Basin impact the ability to meet future allocations to Basin states?

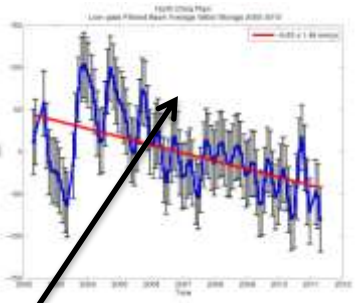
A: No doubt!



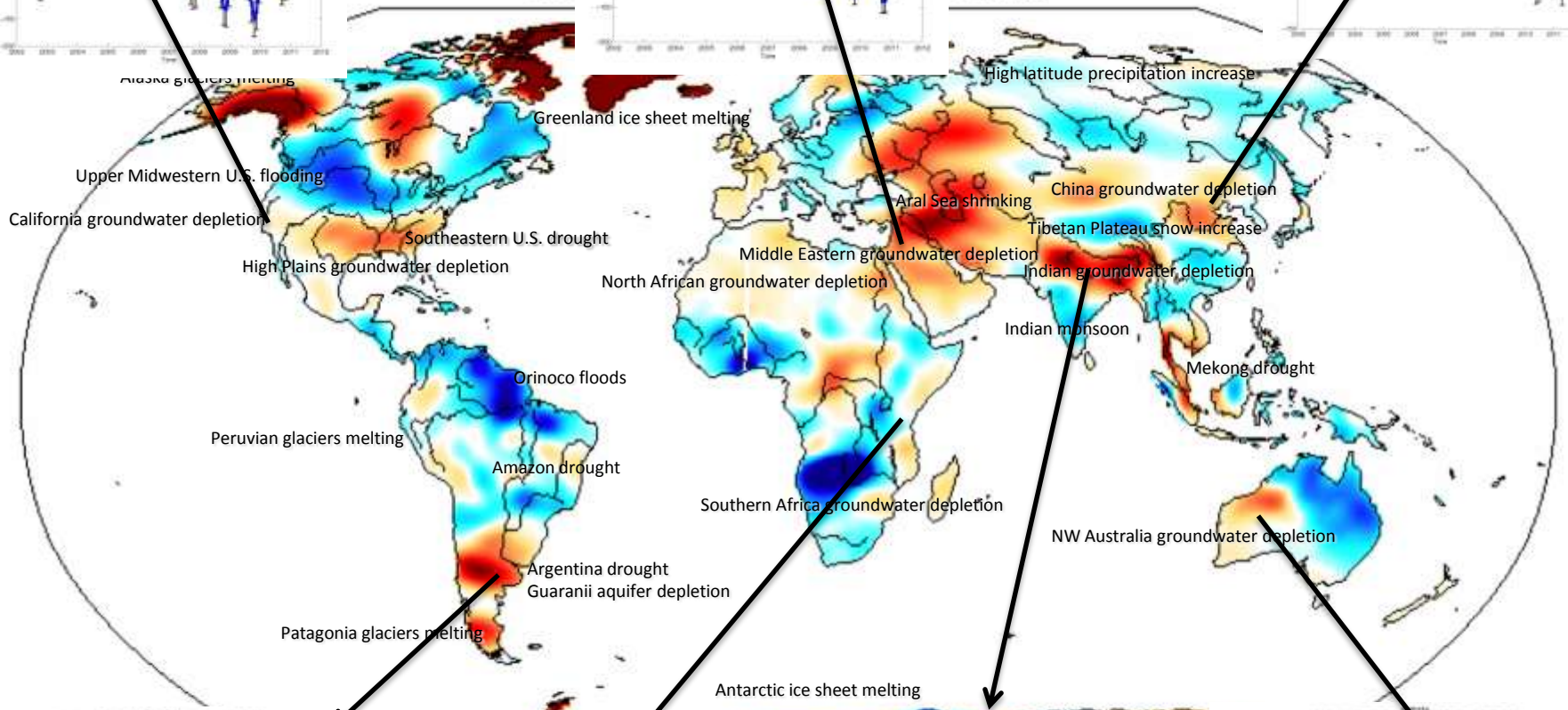
ds in Freshw RACE (2003-2013)

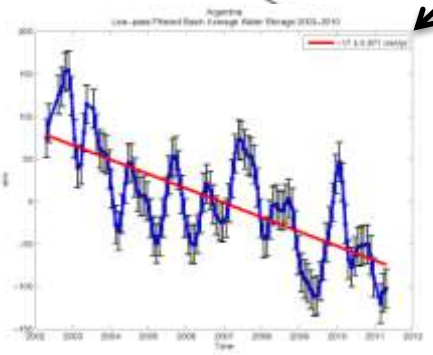


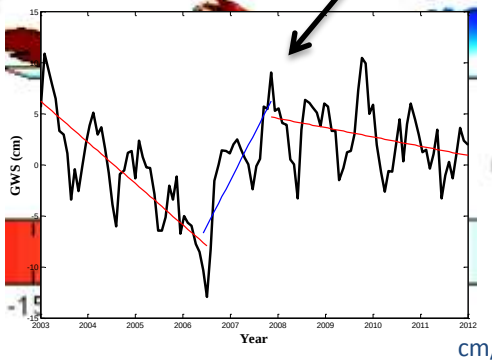


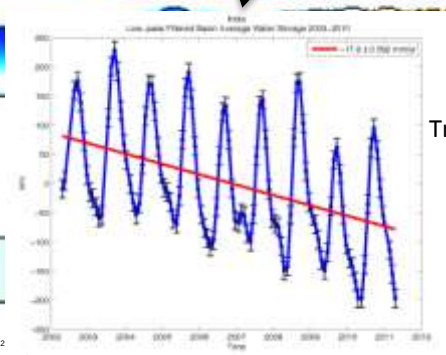


trend [mm/yr]

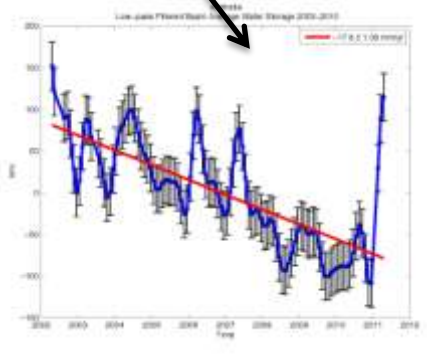






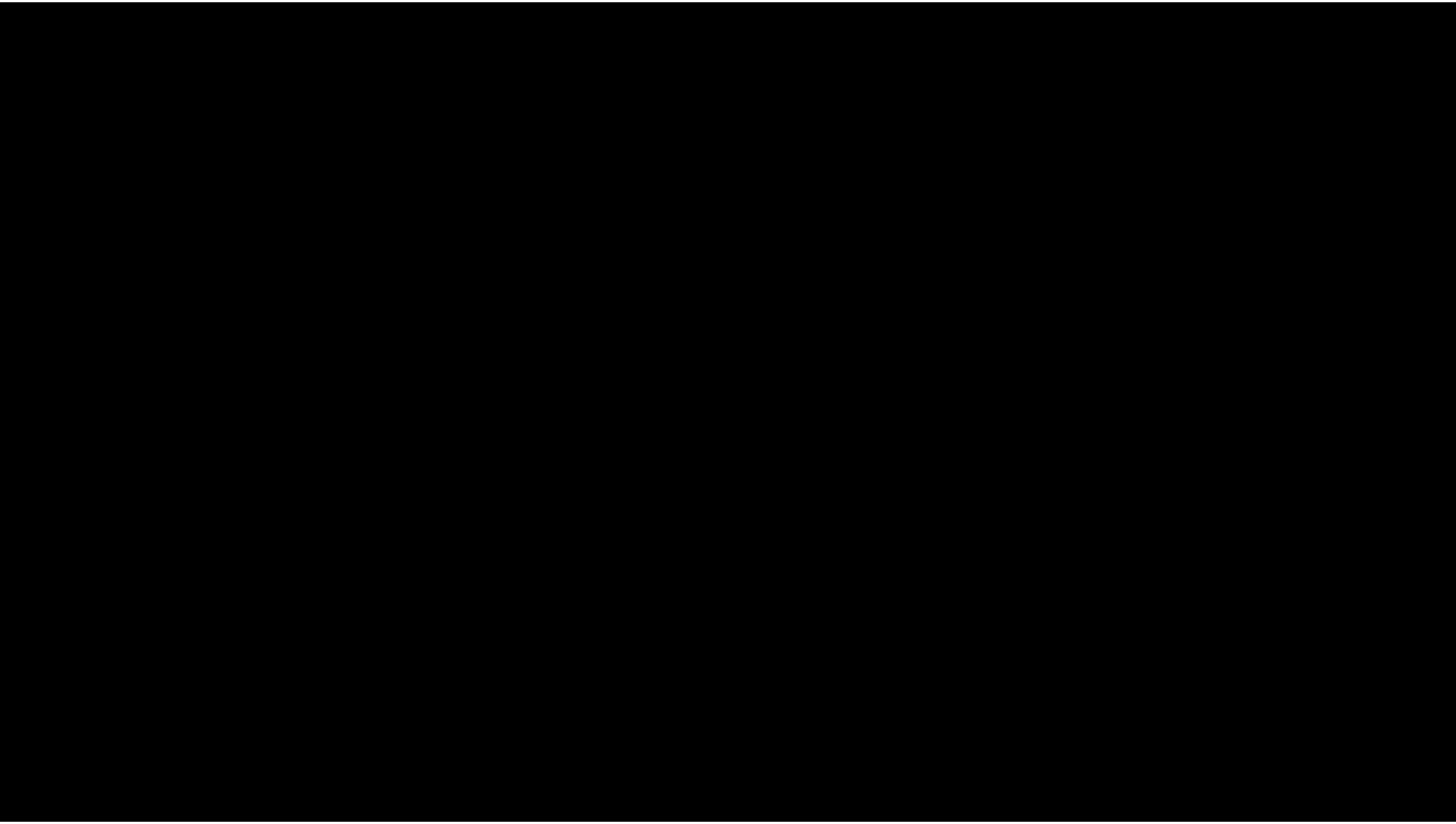


Trend



cm/yr

The Communication Challenge



From ‘Last Call at the Oasis,’ Participant Media/ATO Pictures

Los Angeles Times | OPINION

California's water house of cards

By Jay Famiglietti and Sasha Richey

September 23, 2013

We must raise awareness of the state's critical water issues to the level of everyday understanding.

Once people truly understand that our groundwater is disappearing and not coming back, acceptance of the need for careful monitoring is far more likely.

Irony


Groundwater
Replenishment System
Groundwater
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Replenishment System